What's in This Presentation

- ✧ Introduction to remote sensing
- ✧ How Landsat, a land-observing satellite, works
- ✧ How teachers and students can answer questions about nature with Landsat images

We recommend this set of 19 PowerPoint slides as an easy start in remote sensing with Landsat.

*It will take only about **10 minutes** to review the slides.*

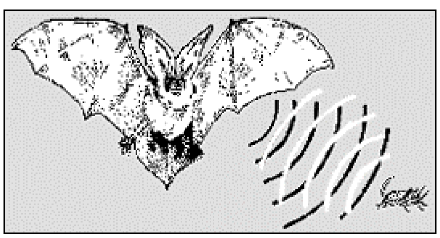
If you wish to review the notes pages, add 10 more minutes to the time required.

Remote Sensing Overview

- **What is remote sensing?**
  - Observing or measuring things from a distance
- **How is remote sensing useful?**
  - It enables us to study nature in ways that would otherwise be beyond human capability, across great distances and at wavelengths of light invisible to human eyes.
- **How is remote sensing done?**
  - By employing special detectors to record light as it's emitted or reflected by the objects of interest to us; and
  - By studying and manipulating the recorded images we get, so that we can answer our questions about nature and how people affect it.

What Is Remote Sensing Anyway?

In its broadest definition, remote sensing means collecting information about an object without being in direct physical contact with it: learning without touching. The most familiar kind of remote sensing is the use of our eyes to detect light. We also use remote sensing when we hear, and when we feel heat that radiates from a warm object.



Bats sense their environments by emitting sound waves (shown above in black). The sound waves hit objects and are reflected back (shown above in white) to the bats. The time it takes for the reflected sound waves to get back to the bats indicates to them how far they are from insect prey, trees, and other objects around them.

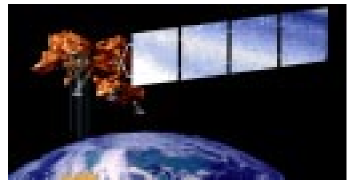
We use remote sensing when we hear in everyday situations. When a car honks its horn, we immediately focus all our attention on it to learn whether or not we are in danger. We also use sound waves to make medical images (ultrasound) and to look for submarines (sonar) from a ship. Animals use sound waves in sophisticated ways. Bats use them to find insects and to find their way through their surroundings.

When we sit near a fire, we sense its radiant energy (heat). This is a form of remote sensing! Other animals can sense heat even better than we do. Rattlesnakes use special organs on their heads to detect heat radiation from small prey animals such as mice.

What Can We Study with Remote Sensing?

➔ **Land, air, water, rocks, living things, ice and snow**

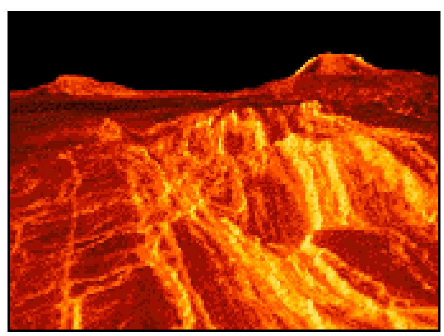
For example:



- Climate change and its effects
- Productivity of grasslands
- How human activities change land cover
- Landforms we can’t see from the ground
- Photosynthesis on land and in the ocean
- Air quality: chemicals and particles (aerosols)
- The extent of natural hazards such as volcanoes, floods, and drought
- Shifting ecosystem boundaries: deserts, forests, and wetlands

What Is Remote Sensing Anyway? (Continued)

We don't know of any animals that can detect x-rays directly, but humans have developed X-rays as valuable probes of the hidden world. X-rays are used in medicine to find broken bones and to examine the condition of internal organs.



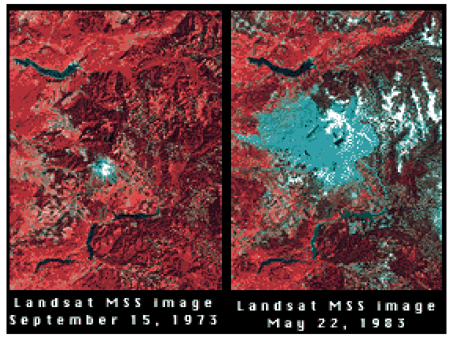
At upper left, X-rays show bones under the skin . At upper right, radio waves from NASA’s Magellan satellite have penetrated clouds to show us the surface of Venus.

Satellites use remote sensing, too. A satellite gathers information about something it is not in contact with, and sends that information to people on the ground. Some satellites use special detectors to make images. The detector, or sensor, is what the satellite uses to sense, or gather, the information.

Satellites use many types of sensors to observe things that people can't observe with our eyes alone. In somewhat the same way a doctor uses x-rays to see bones under the skin, the NASA satellite Magellan has used radio waves to see through the dense clouds that shroud the surface of the planet Venus, and has sent the image back to Earth.

Remote Sensing Gives Us the Big View

➢ With remote sensing, charting changes in the Earth’s land, oceans, and atmosphere becomes more comprehensive, easier, quicker, and often less expensive.

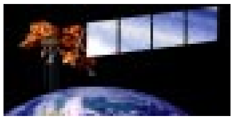


These Landsat images show Mount St. Helen's before and after its 1980 eruption. The light blue in the image at upper right shows the zone of destruction to the north of the volcano’s original summit.

. Remote sensing pictures are used every day by:

- Archaeologists searching for ancient ruins
- Mapmakers
- Relief workers when there is an earthquake, flood, or volcanic eruption
- The Coast Guard to help ships avoid icebergs
- Urban planners who need data for land use analysis
- Geologists to find minerals, oil or geothermal sources
- Ship captains to save fuel by following ocean currents
- Farmers to assess insect damage
- Weather forecasters and climate researchers
- The fishing industry to locate the best areas for fishing
- Military reconnaissance experts
- Astronomers

There are hundreds for uses of remote sensing.
New ones are being developed every year.



Where does remote sensing fit in the curriculum?

♦ ***With remote sensing, we can teach —***

Agriculture, the atmosphere, biology, the carbon cycle, chemistry, Earth system science, ecology, geography, geology, global environmental change, hydrology, land use, landforms, mapping, natural hazards, oceanography (physical, biological, and geological), planetary geology, weather and climate

— and more.

Expanding Students' Views of the Planet

Satellite images expand possibilities for monitoring and analyzing critical environments everywhere. Students gain valuable insights into the nature of their own environments, and they can share these insights with students around the world. Ecology students can investigate natural and human-induced changes in land use patterns and the global distribution of major biomes. Chemistry students can relate these changes to increases in greenhouse gases, and oceanographers can study physical, chemical, and biological processes at the atmosphere-ocean interface (i.e. the sea surface).

Winston Churchill is credited with having said that the farther away from something one gets, the farther into the future one sees. With remote sensing images, students worldwide can step into space and view their home as a whole, as a self-contained life-support system powered by the sun. How fast has it and will it adapt to changes of various kinds, and what are the consequence for our local communities? By viewing the Earth in satellite images and developing an understanding of the stories those images tell, all of us can gain a deeper appreciation for where we live, and for our connections to local and global ecosystems.

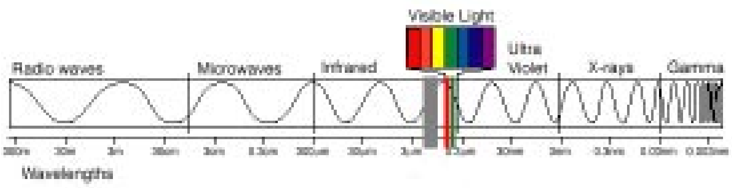
What can students do with remote sensing?

Students can…

- Study their own neighborhoods from the perspective of space
- Map urban growth
- Measure the extent of lava flows, glaciers, floods, and drought
- Describe changes in land cover over large areas
- Find forest fires, and monitor vegetation recovery over time
- Check the health of coral reefs
- Evaluate water quality in a lake
- Assess damage to a coastline after a hurricane
- Estimate plant photosynthetic activity

How does remote sensing work?

» *By sensing and measuring radiation* «



The Electromagnetic Spectrum

> **Remote sensing uses the radiant energy that is reflected and emitted from the Earth at various wavelengths of the electromagnetic spectrum.**

> **Our eyes are sensitive only to the *visible* wavelengths of the EM spectrum. Special sensors help us to capture the rest, and to translate it into a form we can see and understand.**

What we can see is only a tiny fraction of the light in the universe.

For a helpful five-minute introduction to the electromagnetic spectrum, go to:

http://imagers.gsfc.nasa.gov/ems/index.html

How can we tell what we're looking at in a remote sensing image?

◊ Everything reflects and emits energy at characteristic wavelengths.

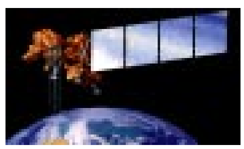
We know this is Crater Lake, Oregon, not only because of its rounded shape and where the satellite was pointed when the image was made, but because we know that water looks black in this kind of image.

In remote sensing images like this one from Landsat, we can learn about the Earth in useful ways.
The image at right shows North Carolina's Outer Banks after a hurricane.

Hurricane forces churned up sediment in the water. The resulting turbidity makes the water appear "cloudy" in this Landsat image.

What's special about Landsat?

- Landsat has been observing the Earth continuously over a long period of time.
- Landsat covers all of the Earth's land surface at high resolution (captures lots of detail).
- Landsat provides affordable images for learning and teaching.



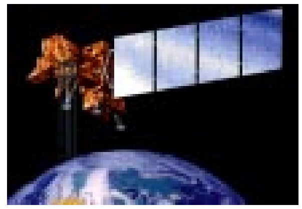
Landsat is unique.

◊ Landsat has observed the Earth's surface continuously and consistently since 1972.

◊ Landsat has a 16 day repeat cycle. Landsat observes all of the Earth's continental surfaces, at multiple wavelengths of the electromagnetic spectrum.

◊ The US Geological Survey EROS Data Center provides Landsat scenes for $600 per scene, less than the previous price of approximately $5,000 per scene. Teachers can get some Landsat scenes for free and others at very low cost.

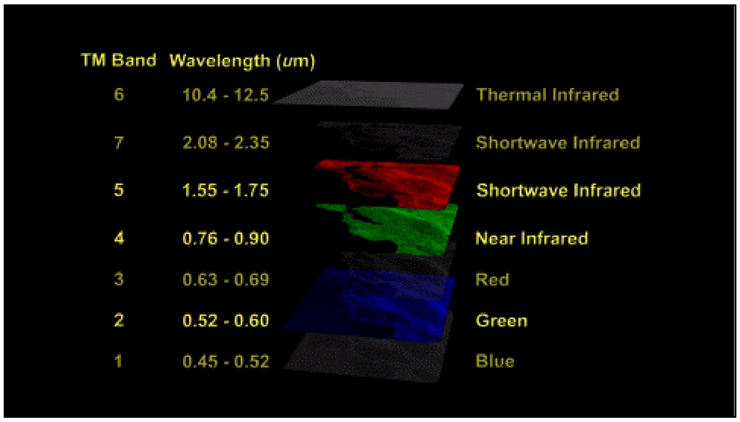
How Does Landsat Work?



Overview of the next five slides:

- *Landsat observes radiation at **seven wavelength ranges**, or bands, of the EM spectrum.*
- *You can display any **three** of those seven spectral bands at one time.*
- *Landsat images are made of **pixels** (picture elements).*

Landsat observes radiation at seven wavelength ranges, or bands, of the EM spectrum.



Each band is assigned a number from 1 to 7.

Landsat Spectral Bands

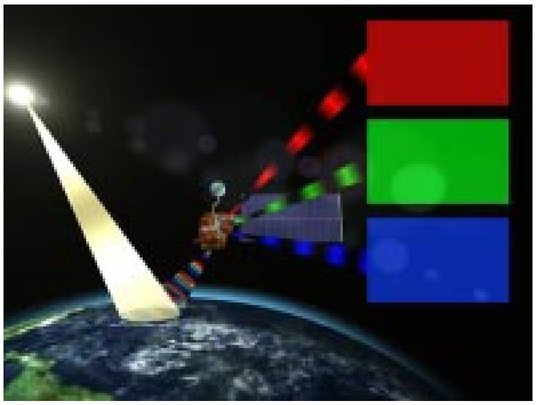
Band 1: 0.45 - 0.52 µm (Blue). Band 1 is useful for mapping water near coasts, differentiating between soil and plants, and identifying manmade objects such as roads and buildings.

Band 2: 0.52 - 0.60 µm (Green). Spanning the region between the blue and red chlorophyll absorption bands, this band shows the green reflectance of healthy vegetation. It is useful for differentiating between types of plants, determining the health of plants, and identifying manmade objects.

Band 3: 0.63 - 0.69 µm (Red). The visible red band is one of the most important bands for discriminating among different kinds of vegetation. It is also useful for mapping soil type boundaries and geological formation boundaries.

Band 4: 0.76 - 0.90 µm (Near infrared). This band is especially responsive to the amount of vegetation biomass present in a scene. It is useful for crop identification, for distinguishing between crops and soil, and for seeing the boundaries of bodies of water.

Each image use only <u>three</u> of the seven spectral bands. Why?



The human eye is not sensitive to ultra-violet or infrared light. To build a composite image from remote sensing data that <u>makes sense to our eyes</u>, we must use colors from the visible portion of the EM spectrum — red, green, and blue.

Landsat Band Descriptions (continued)

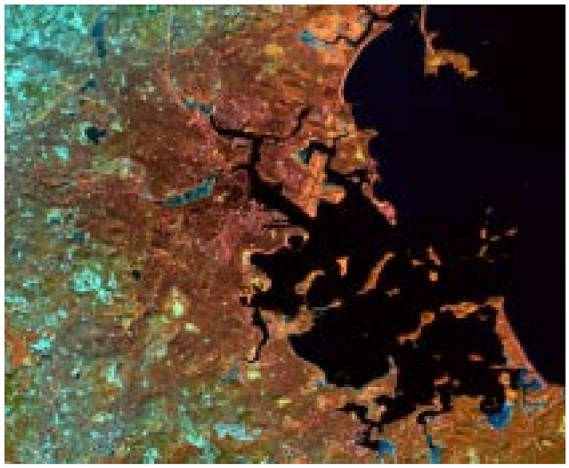
Band 5: 1.55 - 1.75 µm (Mid-Infrared). This reflective-IR band is sensitive to turgidity -- the amount of water in plants. Turgidity is useful in drought studies and plant vigor studies. In addition, this band can be used to discriminate between clouds, snow, and ice.

Band 6: 10.4 - 12.5 µm (Thermal infrared). This band measures the amount of infrared radiant flux (heat) emitted from surfaces, and helps us to locate geothermal activity, classify vegetation, analyze vegetation stress, and measure soil moisture.

Band 7: 2.08 - 2.35 µm (Mid-infrared). This band is particularly helpful for discriminating among types of rock formations.

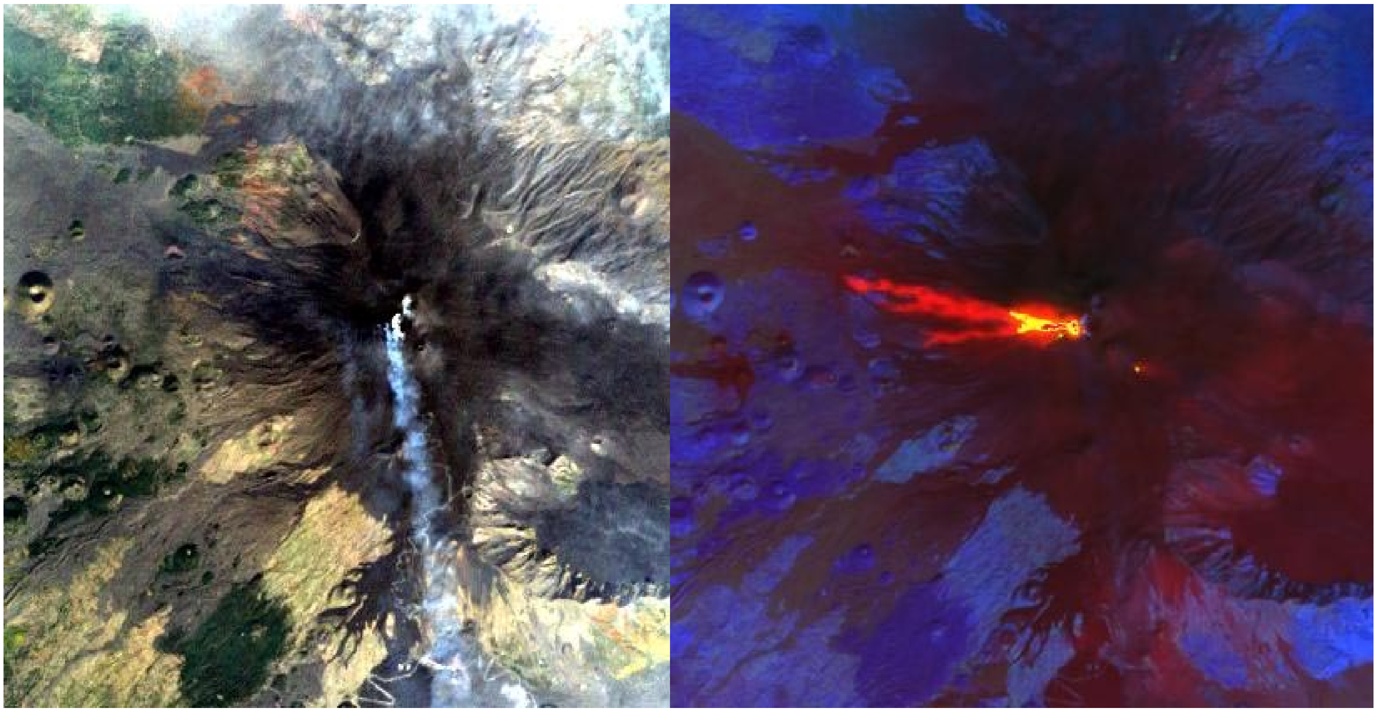
- ***People choose which three of the seven bands they want to use for any given image.***

There are lots of possible combinations.



This image of Boston uses the "5, 4, 2" combination, for what appears to our eyes as red, green, and blue. What appears to our eyes as red is actually radiation in the Band 5 wavelength range; what appears to us as green is actually Band 4; and what appears as blue is Band 2.

Different combinations of bands show different things about the land surface.



Mount Etna volcano: One set of data, two different band selections. Above left, the 3, 2, 1 band combination shows a smoke plume . Above right, the 6, 5, 4 band combination shows lava flows. Both features of the volcano are recorded in the same Landsat image, but appear best with different band combinations.

SOME BAND COMPOSITES

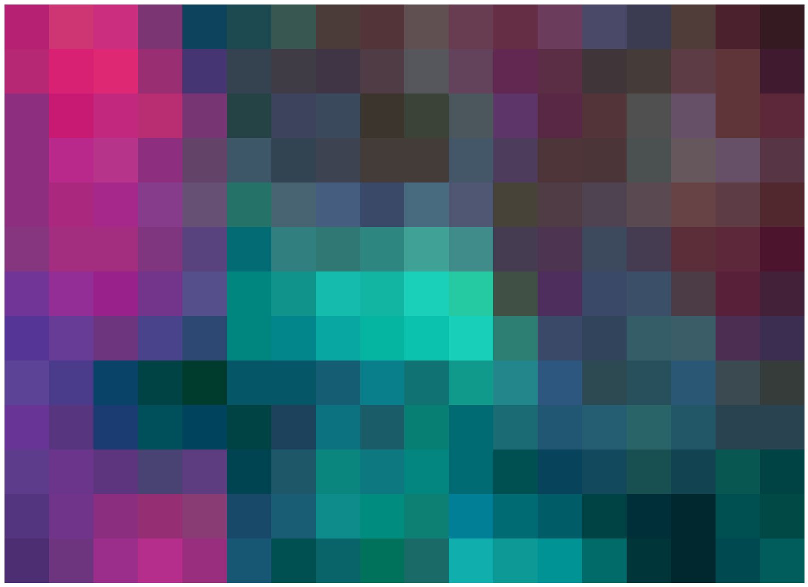
True-Color Composite (3,2,1)
True-color composite images approximate the range of vision for the human eye, and hence these images appear to be close to what we would expect to see in a normal photograph. True-color images tend to be low in contrast and somewhat hazy in appearance. This is because blue light is more susceptible than other bandwidths to scattering by the atmosphere. Broad-based analysis of underwater features, determination of water quality and suspended sediments are representative applications for true-color composites.

Near Infrared Composite (4,3,2)
Adding a near infrared (NIR) band and dropping the visible blue band creates a near infrared composite image. Vegetation in the NIR band is highly reflective due to chlorophyll, and an NIR composite vividly shows vegetation in various shades of red. Water appears dark, almost black, due to the absorption of energy in the visible red and NIR bands.

Shortwave Infrared Composite (7,4,3 or 7,4,2)
A shortwave infrared composite image is one that contains at least one shortwave infrared (SWIR) band. Reflectance in the SWIR region is due primarily to moisture content, vegetation structure and vegetation type. SWIR bands are especially suited for camouflage detection, change detection, disturbed soils, soil type, and vegetation stress.

Landsat Images Are Made of Pixels

(picture elements)

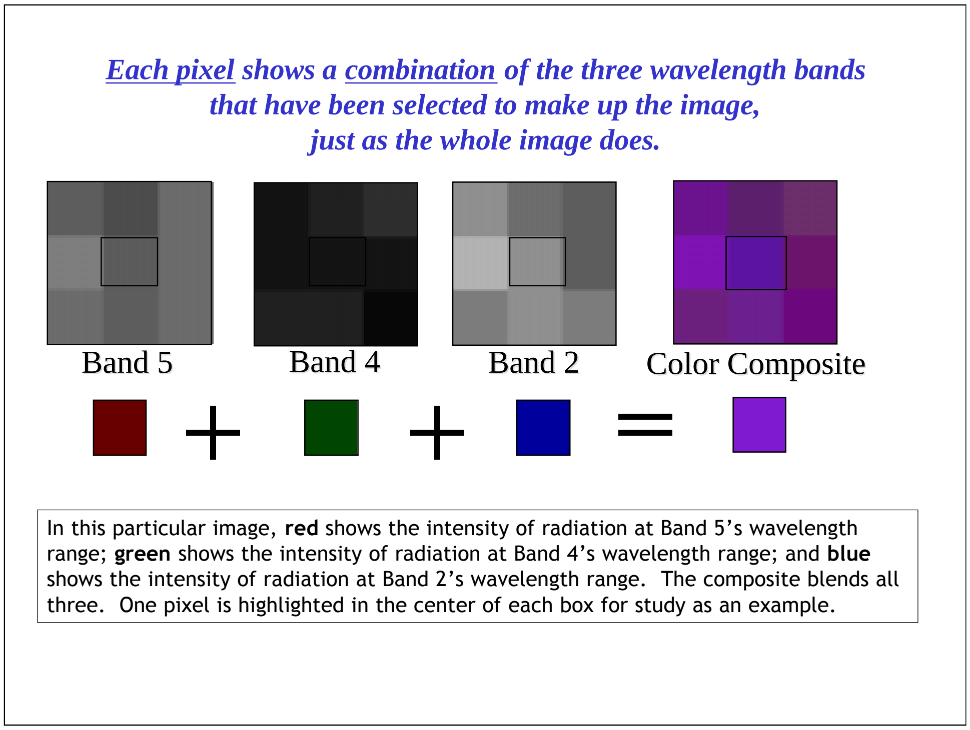


- Just like the pictures on your television set, satellite imagery is made up of tiny squares, each a different color or shade of gray. These squares are called pixels—short for picture elements—and represent the reflected light energy recorded for that part of the image.

- This Landsat satellite image has been magnified to show its individual pixels. On Landsat 7's ETM^{+} instrument, each pixel represents an area 30 m x 30 m, or 900 m^2 . Every pixel in a Landsat image shows the intensity of radiation at each of the three wavelength bands, on a scale of 0-255.

- That 30-meter number for Landsat 7's ETM is a measure of the instrument's resolution, or the extent of detail that it can show. Landsat bands 1, 2, 3, 4, 5 and 7 have a 30 meter resolution. Landsat 7 band 6, the thermal infrared, has a 60 meter resolution. Higher resolution such as 1 meter (smaller land area per pixel) means that an instrument can record more detail. Landsat 7's 30 m resolution is very high for a satellite that must cover the entire globe every 16 days.

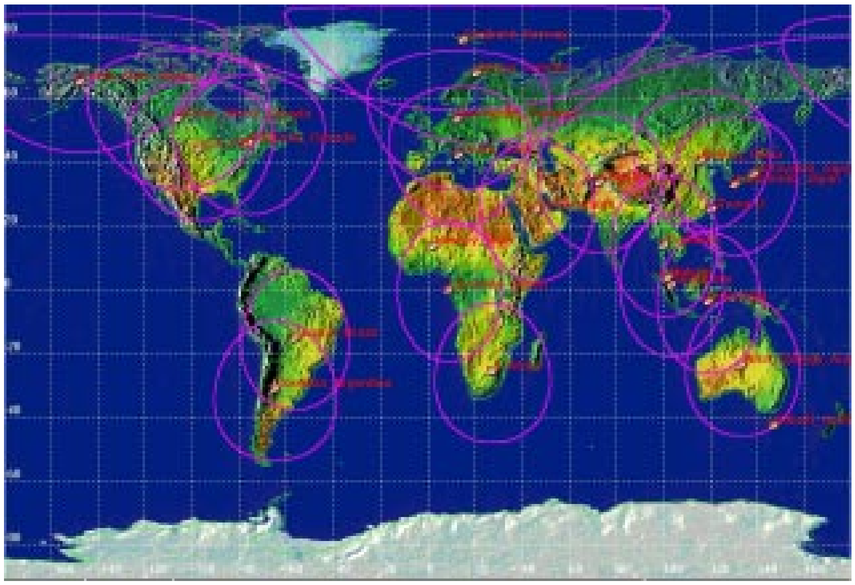
- By adding up the number of pixels in an image, students can calculate the area of land cover type in a scene. For example, if red in a false-color image represents vegetation, students can count the number of red pixels and multiply that number by the area of each pixel to determine the total area covered with vegetation.



Enhanced Color Composites

Image processing software including MultiSpec generates a satellite image using three spectral bands (wavelength ranges) of data, and combines them to create a color composite image. The reflected intensities of light in each spectral band appears as shades of gray and the software assigns colors (red, green and blue) to each of the three selected bands. In the slide above showing nine pixels in each of three channels making up the composite, the pixel highlighted in the center of each box can be studied as an example.

Landsat data are sent to ground stations around the world, where scientists, teachers, and students can use it.



Teachers and students can learn to analyze Landsat images.

- ❖ You and your students can use Landsat to get the "big picture" and to pursue your questions about how the Earth is changing.
- ❖ To do this, you can use special software called "MultiSpec". It is available at no cost.
- ❖ When using MultiSpec for the first time, use the GLOBE MultiSpec Tutorial provided on this website.
- ❖ To download the MultiSpec software itself, go to: http://dynamo.ecn.purdue.edu/~biehl/MultiSpec/

Computers in classrooms today can process and manipulate Landsat data. Students can create new visualizations of satellite scenes in a matter of seconds. They can make observations, and test their hypotheses by following their hunches to logical conclusions with a few simple steps during one class period.

If you have a group of teachers who would like to learn how to investigate our changing land with MultiSpec, contact:

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